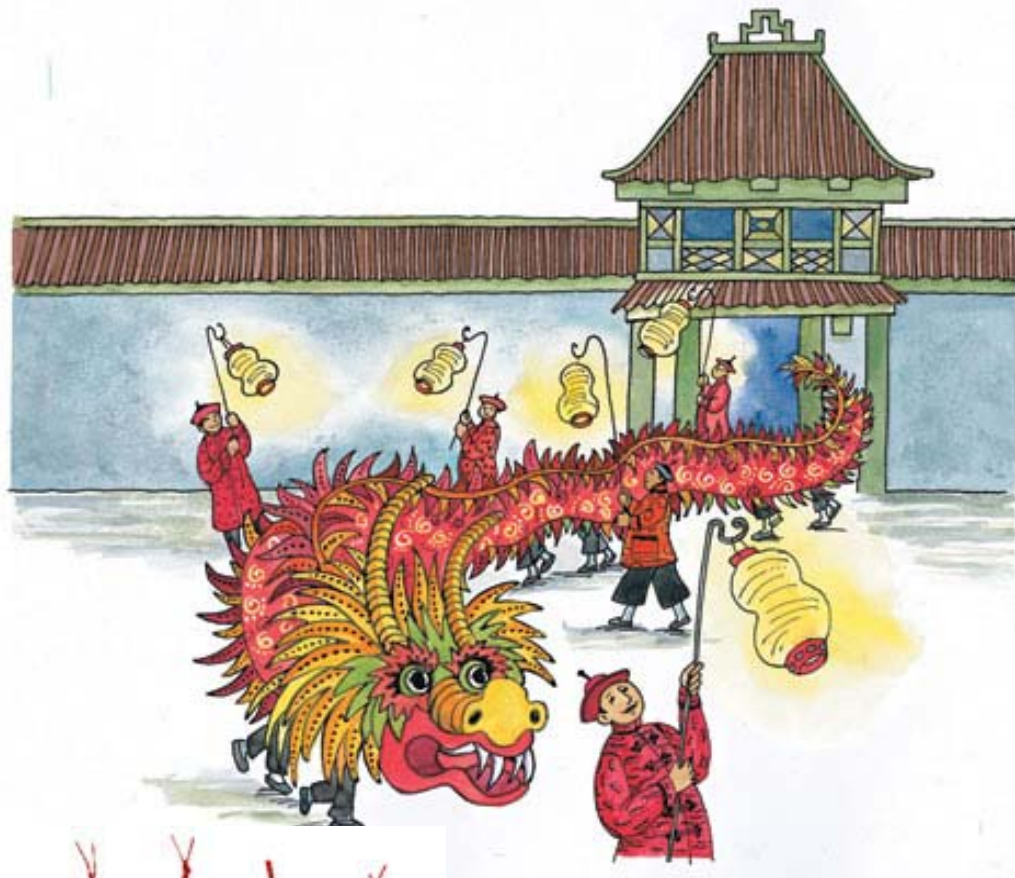




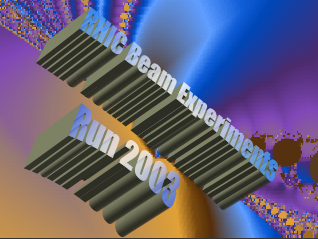
Beam Experiments At RHIC

Fulvia Pilat



*Chinese New Year
a. k. a. January 31, 2003*

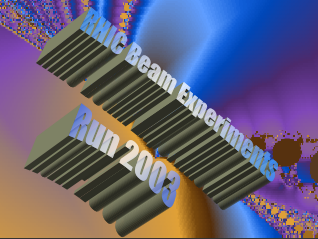




Beam Ex at RHIC: Outline

- ❑ Goals & 'boundaries'
- ❑ Brief history (2000→2003)
- ❑ Program for run 2003
- ❑ Organization: AEAC, scheduling, beam ex 'life-cycle',
comparison with other machines

- ❑ Beam experiments 2003 so far: results (preliminary)
- ❑ Near term future: next Wednesday
- ❑ Medium term future: rest of Run 2003
- ❑ Long(er) term future: RHIC beyond 2003



Beam Ex: goals/boundaries

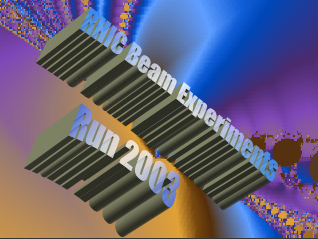
GOALS

- ❑ Improve machine **performance** (longer time scale than 'now' machine performance)
- ❑ **Luminosity** increase, upgrade (RHIC-II)
upgrades are not straightforward (HERA, Tevatron)
effort and investment are needed to prepare them
- ❑ **Inter-lab collaborations** (common goals, exploit synergies, exchange personnel, remote ops? etc.)

Beam experiments → operations

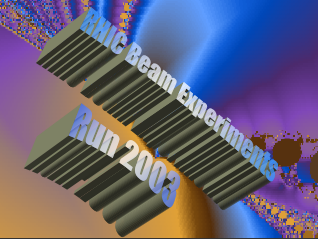
Examples 2001:

- ❑ IR correction, linear → nonlinear
- ❑ Chromaticity measurements via radial excitation
- ❑ Octupole compensation



RHIC Beam Ex milestones

- ❑ Workshop on Accelerator Physics Experiments on Future Hadron Colliders – BNL February 2000
(www.cadops.bnl.gov/LHC/org/Beam2000/index.html)
- ❑ Run 2000
- ❑ RHIC Retreat 2000, November 2000
- ❑ Run 2001 (www.cadops.bnl.gov/AP/RHIC2001/BeamStudies)
- ❑ Retreat 2001 – March 2002
(www.c-ad.bnl.gov/RHIC/retreat2002/)
- ❑ Workshop September 2002
(www.cadops.bnl.gov/AP/RHIC2003/BeamEx2003/Workshop)
- ❑ Run 2003 (ongoing)



2001 RHIC Beam Experiments

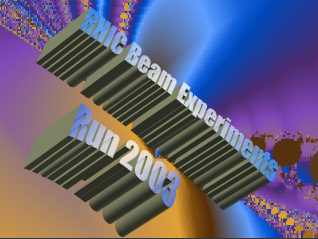
Beam studies program in parallel to Operations and Machine development for

- ❑ Testing new techniques (→operations)
- ❑ Collaborative beam experiments (CERN, FNAL,...)

70 h (gold run) and 20 h (PP run)

Main activities/results:

- ❑ IR measurements/corrections
- ❑ Beam-beam studies
- ❑ Longitudinal and transverse impedance
- ❑ Resonance compensation
- ❑ Spin manipulations
- ❑ Pressure rise investigations / 110 bunches
- ❑ Testing of new decoupling techniques
- ❑ Beam dynamics studies



Beam Ex Program run 2003

AC dipole

Beam-beam

Chromaticity

Collimation

Flattop, Nonlinear, IRs

Instabilities

Pressure rise, e-cloud

Stochastic cooling

Transition

M. Bai

W. Fischer

S. Tepikian

A. Drees

V. Ptitsyn

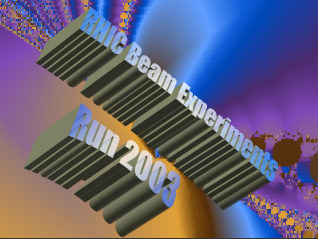
M. Blaskiewicz

S.Y.Zhang

M. Blaskiewicz

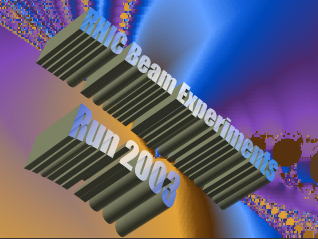
C. Montag

www.cadops.bnl.gov/AP/RHIC2003/BeamEx2003/



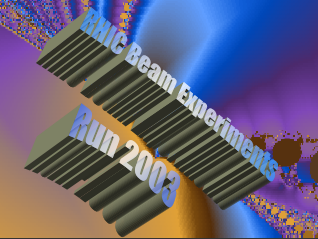
Beam Ex Organization: RHIC 'model'

- ❑ Run organization – beam ex framework
- ❑ Proposal / prioritization (AEAC Committee)
- ❑ Beam Ex weekly cycle
- ❑ WEB tools: Beam Ex webpage, BeamEx logbook
- ❑ Comparison with other machines: LEP, DESY, Tevatron



Beam Experiment time

Run mode	Maximum available time	Requested time (so far)	Recommended time (1/3/2003)
d-Au	132 h (assuming 11 weeks physics)	172 h	93 h
pp	36 h (assuming 3 weeks physics)	32 h	23 h



Beam Ex 2003: run scenario

For each mode in run 2003 (d-Au, PP):

Set-up 2 weeks: start-up, new system commissioning

Ramp-up 3 weeks: luminosity increase

Running ~11 weeks **d-Au** ~3 weeks **pp**

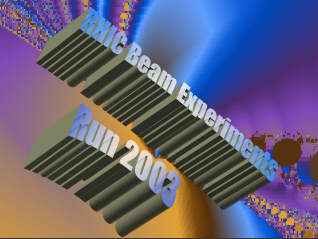
Dedicated beam experiments time during running periods

Preparation activity parasitic to set-up and ramp-up time
(instrumentation, diagnostics, application commissioning, etc.)

Beam experiments time: **12 h/ week**

8 hours (4:00am – 12:00) → experimental access

14 hours (4:00am – 18:00pm) → physics running
(includes time to go back to physics running)



Proposal submission/prioritization

- ❑ WEB based submission system (~45 proposals so far, more upcoming)

- ❑ **AEAC (Accelerator Experiments Approval Committee)**

Set up December 2002 (Kirk, Lowenstein)

Chairman: J. Wei

Members (voting): W. Fischer, S.Peggs, F. Pilat

Members (advisory): D. Lowenstein, P.Pile, T. Roser

Secretary: S.P.Yamin

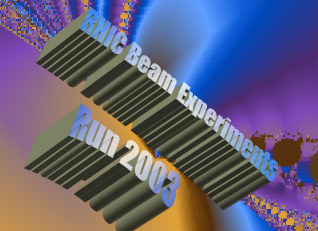
met once (January 3rd), next meeting: February

Prioritization system → AEAC spreadsheet

experiment: **class** (1 2) interest for RHIC

priority (A B C) spin-offs, preparation, likelihood of success

time request/recommendation



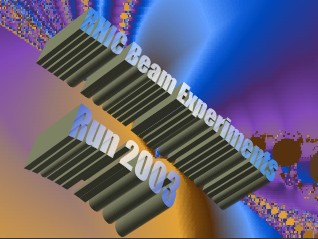
AEAC

January 3, 2003

Beam Experiment Proposal Listing

Version 03-01 (2003-1-3)

Exp. No.	Key words	Spokesperson	Class	Priority	Recomm. time [hour]	Requested time [hour]	Status	Comments
03-1	Optics test with $b^*=0.5$ m (pp at 100 GeV)	F. Pilat		1 A	8	8 (p)		needs matching and ramp
03-2	Diffusion measurements at injection	R. Fliller		1 B	2	1-2	ready	
03-3	Crystal Channeling at Injection	R. Fliller		1 B	2x2	1.5-2	ready	
03-4	Intrabeam scattering	W. Fischer		1 B	3x2	3x2		needs good IPM
03-5	Transverse echos	W. Fischer		1 B	1+2	4 (p)		needs AC quadrupole
03-6	Q' measurement via RF phase modulation and continuous tune	O. Bruning, S. Tepikian		1 B		(2-8 static) + (4-8 ramp)		needs RF phase and PS mod
03-7	Electron cloud and pressure rise	W. Fischer				3+		merged with 03-13
03-8	Electron cloud vs. injection pattern	W. Fischer		1 A	3	3		needs intensity
03-9	Pressure rise in AtR	W. Fischer		1 C	0	0 (parasitic to RHIC)		needs intensity
03-10	Beam-beam	W. Fischer						withdrawn; split into 5 experiments
03-11	Tomographic measurement of α_1	C. Montag		1 A	3x1	3 ramps + (?)	ready	
03-12	Suppression of synchrotron radiation	H. Burkhardt, F. Pilat		2 C	3x2	3x(2-3)		needs presentation
03-13	RHIC electron cloud and vacuum pressure rise characteristics	P. He		0 A	3x2	3x2		merged with 03-7
03-14	Beam Scrubbing	H. Huang		0 A	8	during commission		needs vacuum problem
03-15	Measurements of triplets roll angles and gradients from Action	J. Cardona		1 A/B	1+2	1 per triplet		A for problematic triplet; B otherwise
03-16	Beam polarization profile measurement	H. Huang		1 A	2	2		needs polarized protons
03-17	Sextupole calibration using action and phase analysis on orbit	J. Cardona		1 B	1	1		needs simulation
03-18	Nonlinear Chromaticity	S. Tepikian, V. Ptitsyn		1 A	2	2	ready	
03-19	Tune and coupling drift at injection	W. Fischer						done at commissioning
03-20	Coupling Measurement with the AC dipole	M. Bai		1 A	3+2 (?)	32		prefers later in the run
03-21	Linear Optics Measurements with AC dipole	M. Bai		1 A	3+2	12-16	ready	
03-22	Incoherent tune spread of EC vs. beam-beam, chromatic and	S.Y. Zhang		1		5		needs presentation
03-23	Nonlinear resonance measurements and corrections	V. Ptitsyn		1 B	3x3	2x(3 inj. + 3 top)	ready	
03-24	Beam halo scraping and beam loss effect	V. Ptitsyn		1 A	3	3		needs intensity
03-25	Stochastic cooling feasibility study	M. Blaskiewicz, J.M. Brennan		1 A	2x4	2x(4) + 2x(8) +		needs system setup
03-26	Instabilities in RHIC	M. Blaskiewicz		1 A	0	0 (parasitic)	ready	
03-27	Measure of dynamic aperture at flat-top	F. Pilat		1 B	4	4 for every optics		needs simulation
03-28	Solenoid effect for RHIC electron cloud	S.Y. Zhang		0 A	1+2+2	5		needs intensity
03-29	fast Q' measurement via head-tail technique	P. Cameron, R. Jones		1 A	2+2	2-6		needs system setup
03-30	Beam-beam emittance growth with transverse offsets	W. Fischer		1 A	2x1	2x1 + 1		needs good IPM
03-31	beam-beam tune shifts with long bunches and large	W. Fischer		1 A	2x1	2x1 + 1		needs storage RF
03-32	Beam-beam: Coherent mode generation and suppression	W. Fischer		1 B	4+2	6 (p)		needs polarized protons (injection)
03-33	Measurement of beam-beam resonance driving terms	W. Fischer		1 B	3	3		needs commissioned AC dipole
03-34	Beam-beam: Beam lifetime and background as a function of	W. Fischer		1 A	3	3	ready	pending IR correction



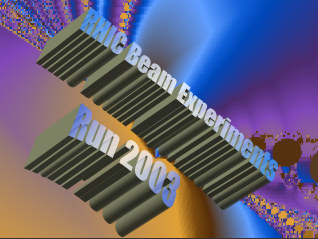
Beam Ex time: ground rules

MCR during Beam Ex time

- ☐ BeamEx Coordinator [FP] may change scheduling/order of experiments in case of “emergencies”
- ☐ OC will inform BEC of all activities concerning operations during Beam Ex time
- ☐ BEC will inform OPS of planned activities the day before (short meeting on Tuesday for info exchange)
- ☐ BEC will call MCR 1h prior to Beam Ex start to coordinate start-up
- ☐ Relevant experimenters and BEC will support OPS to restart physics running if required

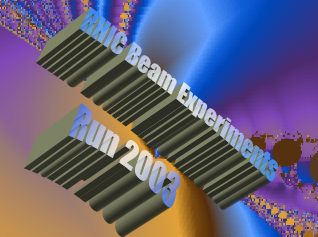
Parasitic/“Other ring” activities

- ☐ intentions declared at the Friday meeting, not in MCR
- ☐ No interference with main experiment in progress
- ☐ If problems, spokesperson of experiment can request BEC to stop parasitic/other ring activities



Beam Ex 2003 'life-cycle'

Monday	<u>Scheduling Meeting</u> (schedule decision) scheduling physicist (1) experiment liaisons (5) run coordinator (1) beam experiments (1) T.Roser, P.Pile
Tuesday	<u>Meeting BE coordinator – OPS</u> (Ingrassia + OC) <u>Time Meeting</u> (broadcast)
Wednesday	BEAM EXPERIMENTS TIME <u>Machine-Experiments Meeting</u> (report, plans)
Friday	<u>Beam Experiments Meeting</u> (discussion of results, schedule for next session)



RHIC Beam Experiments 2003

RHIC Beam Experiments 2003

Send comments to [Fulvia Pilat](mailto:pilat@bnl.gov), pilat@bnl.gov, x3134. Last updated: 01/29/2003 15:52:37

[RHIC Beam Experiments Policy](#)
[Beam Experiments 2001](#)

[List of Beam Experiment Proposals](#)
[AEAC January 3](#)

[Beam Experiment Proposal Form](#)
Next BeamEx: Wed February 5

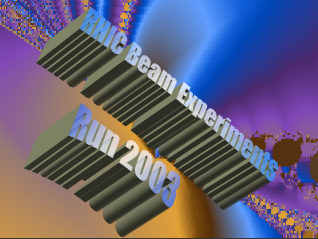
Beam Ex 2003 Organization

Beam Ex Program	Beam Ex Info/Proposals	Beam Ex Material
AC Dipole (M. Bai)	AC dipole memo	
Beam-beam (W. Fischer)	Beam-beam WEB page List of beam-beam experiments	RHIC beam-beam papers
Chromaticity (S. Tepikian)	Chromaticity on the ramp -Horizontal Chromaticity on the ramp - Vertical	chromaticity via head-tail SPS RF phase modulation
Collimation and Background (A. Drees)		
Flattop, Nonlinear, IR (V. Ptitsyn)		
Instabilities (M. Blaskiewicz)	Instabilities memo	
Pressure rise / e-clouds (S.Y.Zhang)	Pressure rise paper	
Stochastic Cooling (M. Blaskiewicz)	Stochastic cooling talk (M.Brennan)	
Transition (alpha-1) (C. Montag)		

RHIC 2003 BEAM EXPERIMENTS WORKSHOP

BNL September 26-27, 2002 [WEBPAGE](#)

<http://www.agsrhichome.bnl.gov/AP/RHIC2003/BeamEx2003>



Comparison with others - LEP

- ❑ **LEPPERC** – chairman S. Myers + invited list of members (~20)
- ❑ 2-3 days MD time every 3-4 weeks
- ❑ Written results prerequisite for more beam time (exception: polarization)

Development time negotiated at the beginning of the run.

Example → run 150 days, 20-30 MD days EXCLUDING run setup

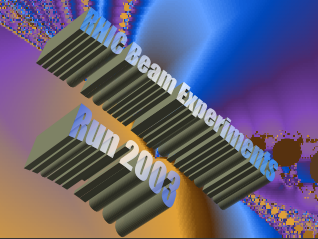
At LEP blocks of 2-3 days (effective if MD time uses a fundamentally different setup, example test of new optics)

With LEP 2 - end of coasts used effectively

Focus changed over the years:

First years: near term machine improvements, upgrades

Late years: more time to 'fundamental' acc phys, other labs (2-3 days for DESY tests, CESR, more formal collaborations)



Comparison with others – DESY, Tevatron

DESY

- ❑ Machine studies and experiments concentrated at the end of the running time, before shutdown(~2 weeks)
- ❑ No formal structure in place to select/organize beam studies. Left to the personal judgement of responsible people for beam development (Hofstatter, Willecke)

Tevatron

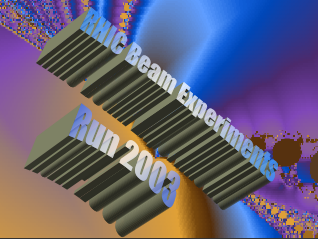
Now: 5 study shifts every other week

Few months ago: 3-4 study shifts every week

Written proposals with WEB submission

(run II coordinator, Tevatron coordinator)

Decision of studies taken at Tevatron department meetings



Beam Ex 2003: results so far

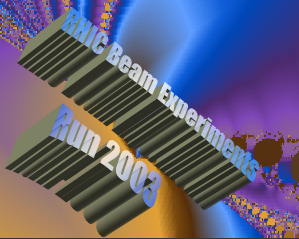
Scheduled time so far: **26 h** (8h + 14h + 4h)

Available beam time: **16 h** (8h + 10h + 0h)

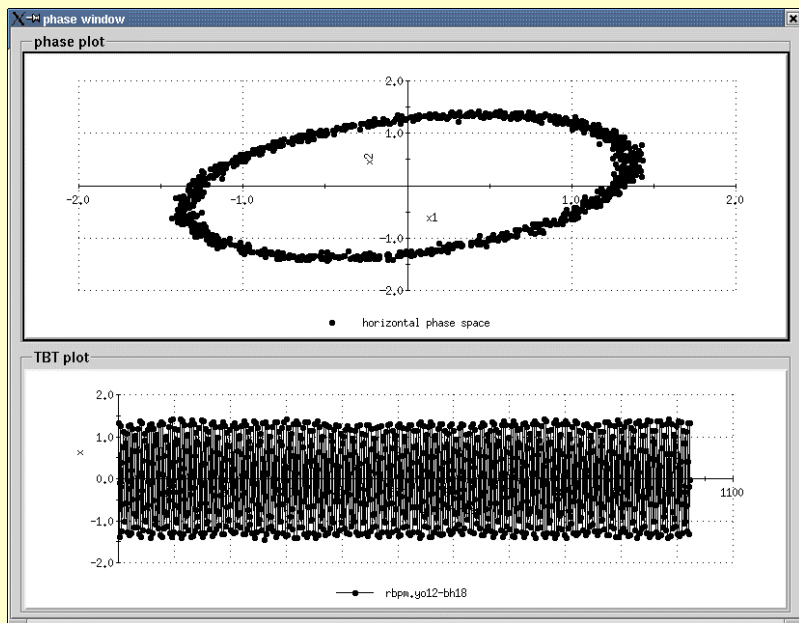
- ☐ AC dipole, linear optics (Bai)
- ☐ Tune scans in collision (blue, yellow) (Fischer, Ptitsyn, Pilat)
- ☐ Non-linear chromaticity (Tepikian, Ptitsyn, Cameron)
- ☐ Resonance compensation (Ptitsyn, Pilat, Fedotov, Cameron)
- ☐ Diffusion at injection (Fliller)
- ☐ Measurement of alpha-1 (Montag)

Parasitic activities:

- ☐ Test of pressure rise IR12 (Zhang, Huang, Hseuh, Ubaldo, Smart)
- ☐ Test of skew quadrupole modulation (Pilat, Cameron, Marusic)
- ☐ Test IR bump application (Pilat, Ptitsyn, Binello)



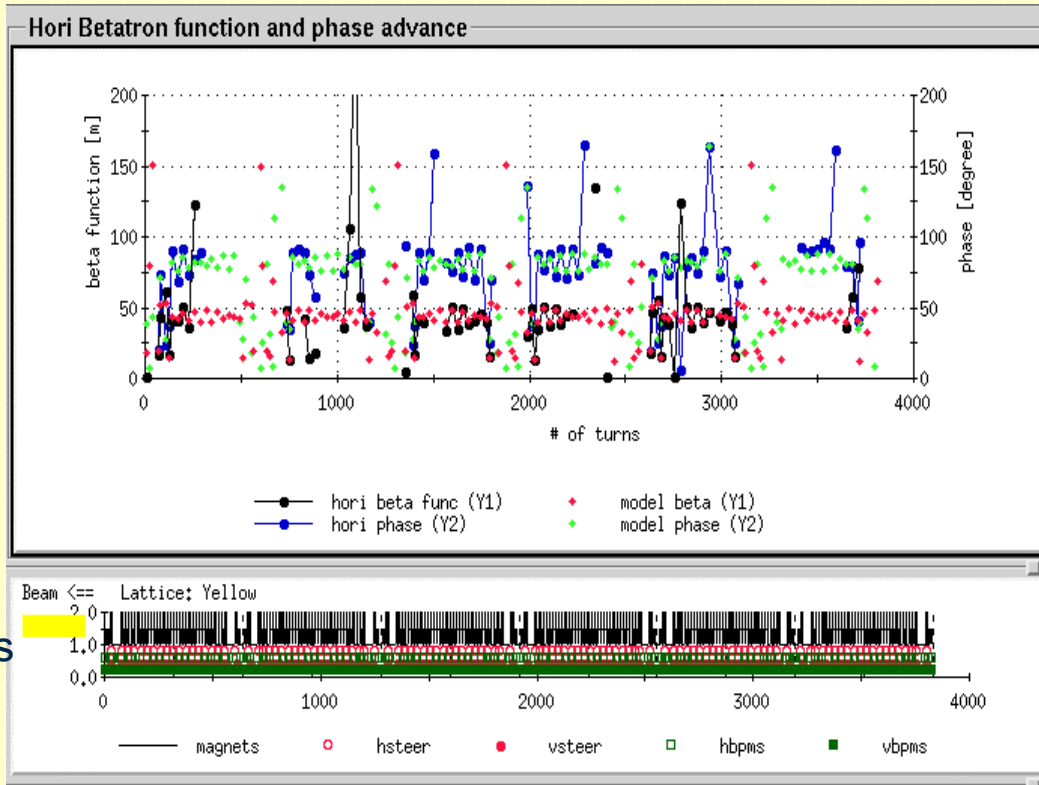
AC dipole – optics measurements - H



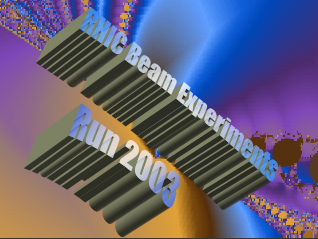
Adiabatic excitation of coherent oscillations
→ emittance preservation

$$z_{coh} = \frac{\Delta B_m L}{4\pi B \rho |v_m - v_z|} \beta_z$$

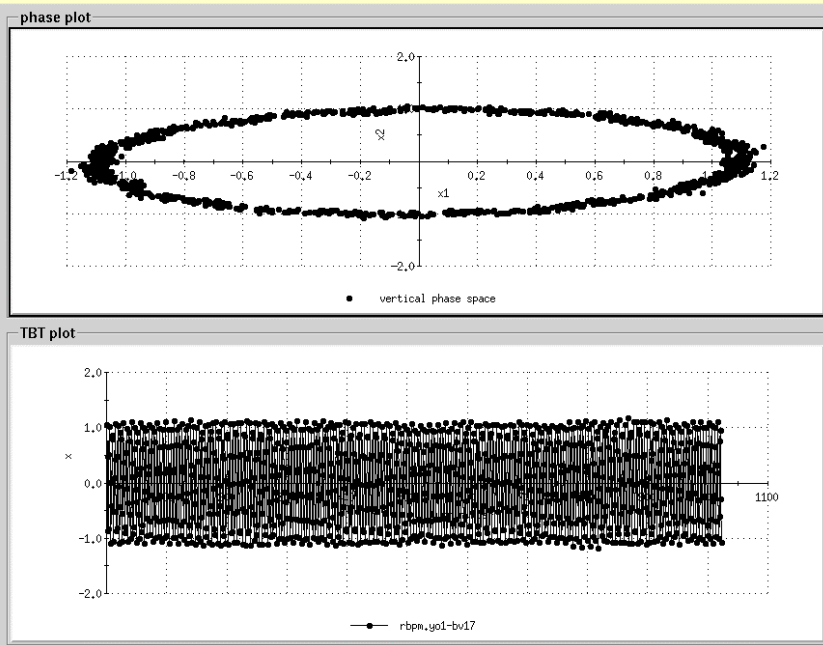
Coherent oscillation amplitude



Application: TBT BPM + AC dipole → betas, phases
Data taken mostly at injection (horizontal)

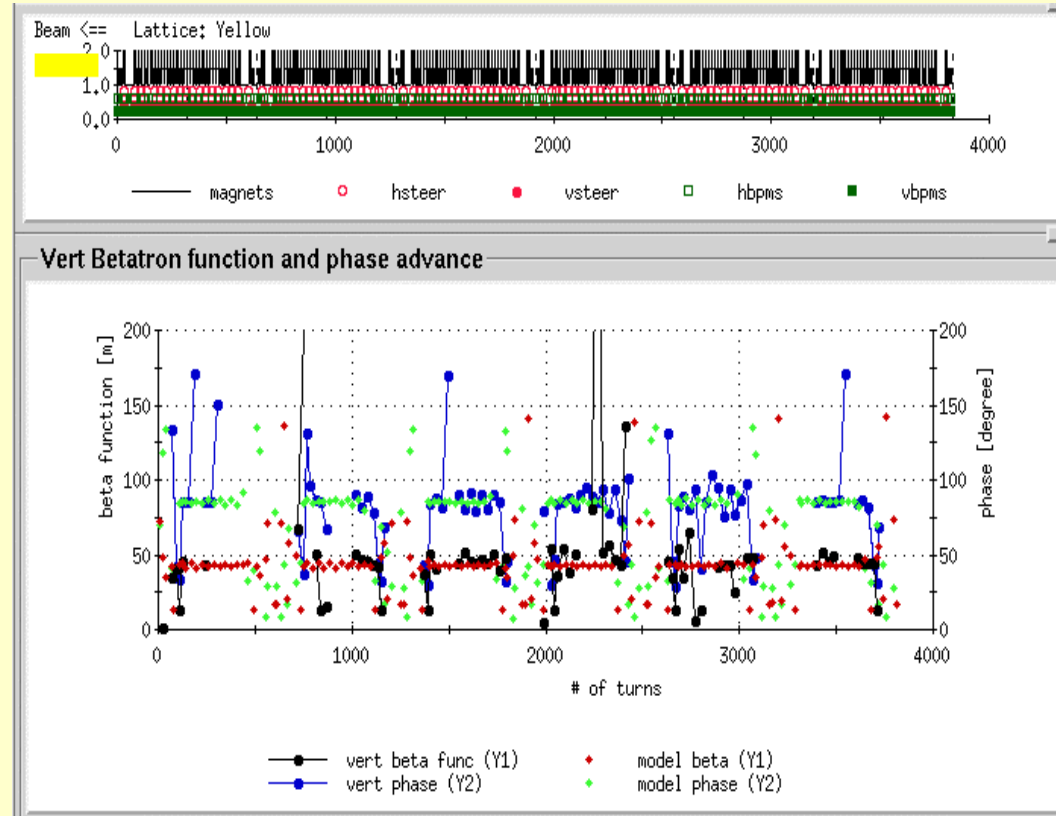


AC dipole – optics measurements - V



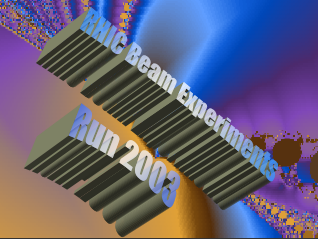
Other applications:

- ☐ Coupling correction (driving terms)
- ☐ Non-linear driving terms
- ☐ Phase space distortions
- ☐ Spin flipping

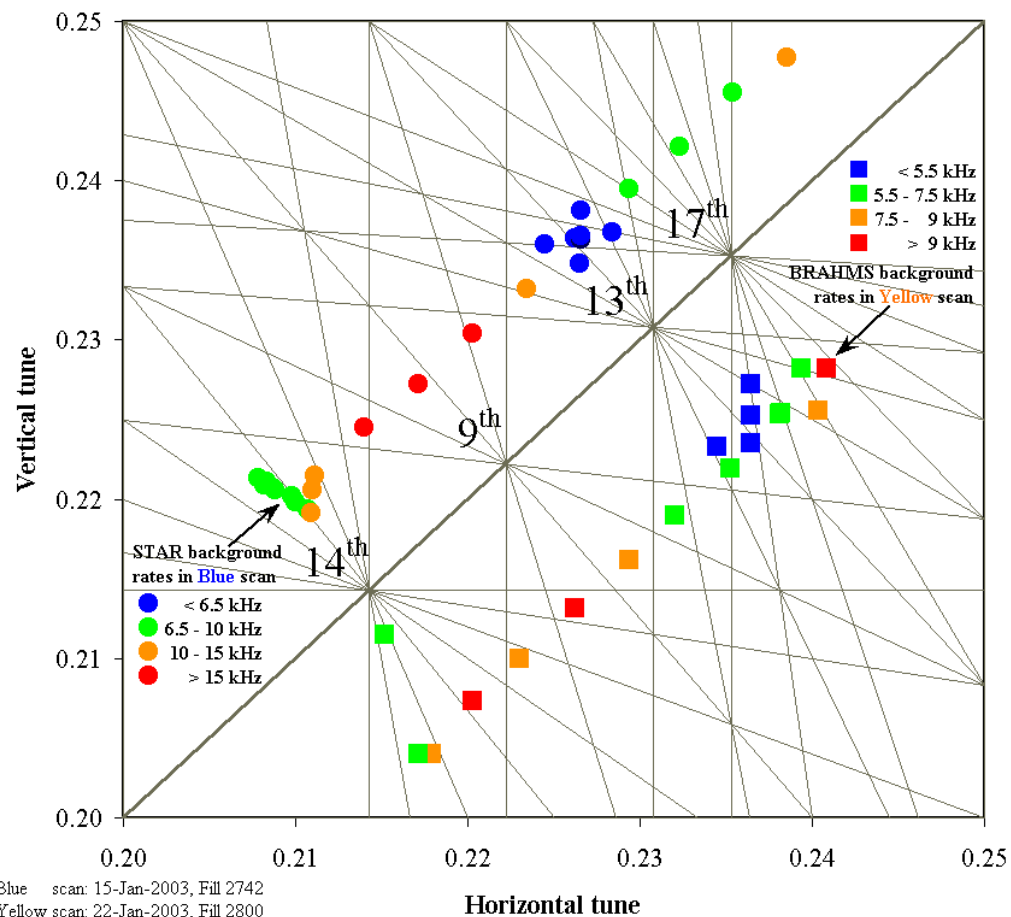


Next step:

- ☐ measurements at flattop
- ☐ IR optics functions



Tune scans in collision



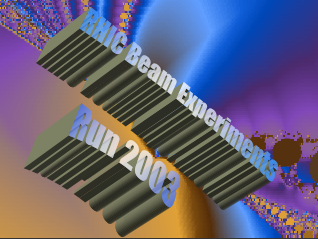
Steps 0.003 in tune along the diagonal
Signals:

- ☐ Lifetime
- ☐ Experimental background
- ☐ Tune monitoring

‘Symmetric’ tunes in blue and yellow

Experiments → Operations

Andy’s application in StartUp to keep tunes in the ‘good box’ (Artus and Schottky when available)



Nonlinear Chromaticity - 1

- ❑ Set radial steering to -0.2 mm
- ❑ Correct linear chromaticity to 0
- ❑ Separate tunes (reduce coupling effects)
- ❑ Compare radial steering shift to bpm
- ❑ Tried various radial steering ramps

Stepped:

5 and 10 steps

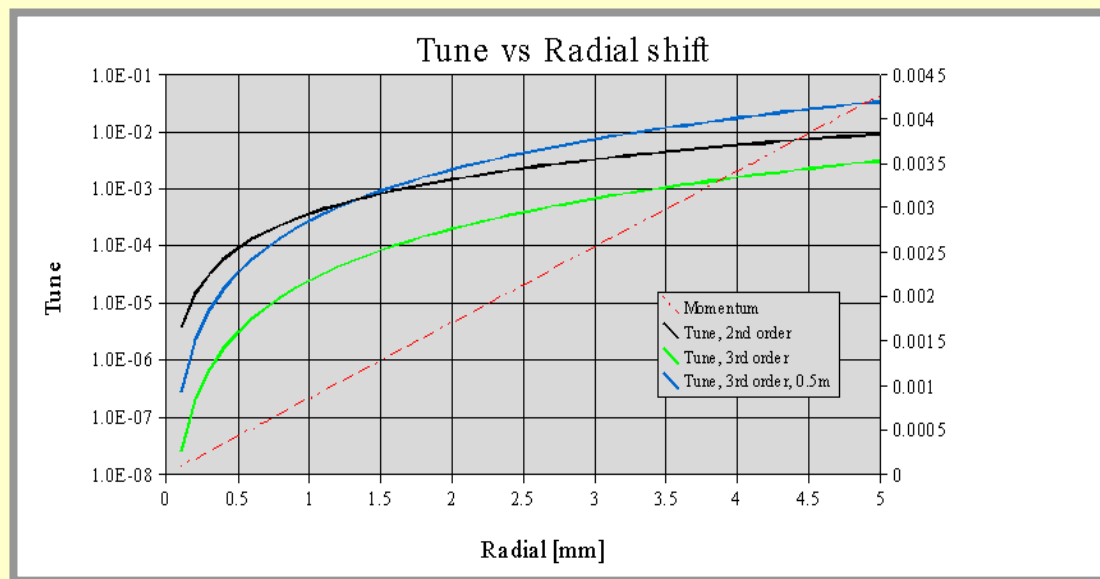
Sine function:

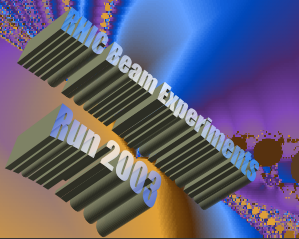
0.4mm amplitude at 1Hz

1mm amplitude at 0.4Hz

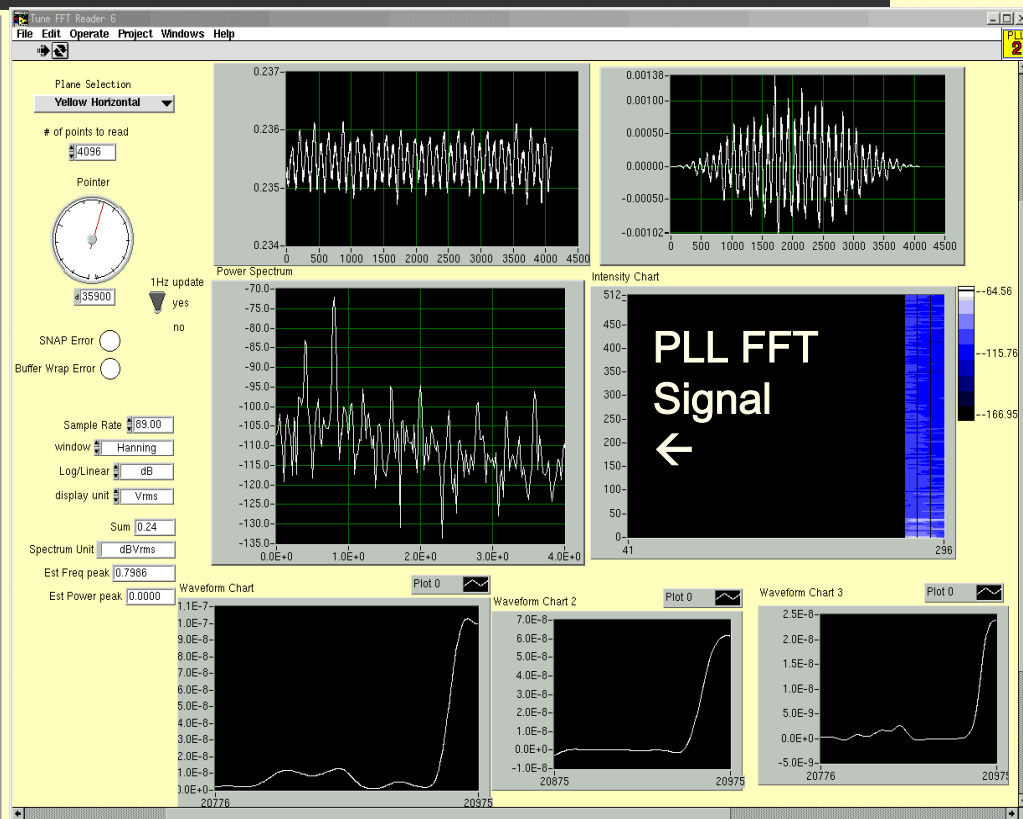
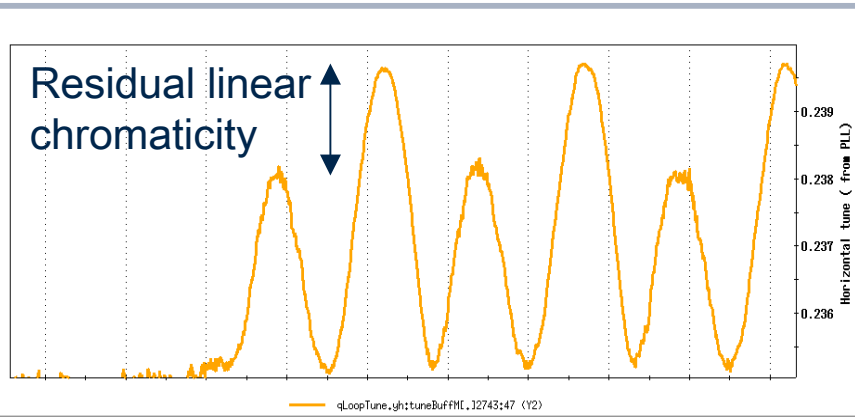
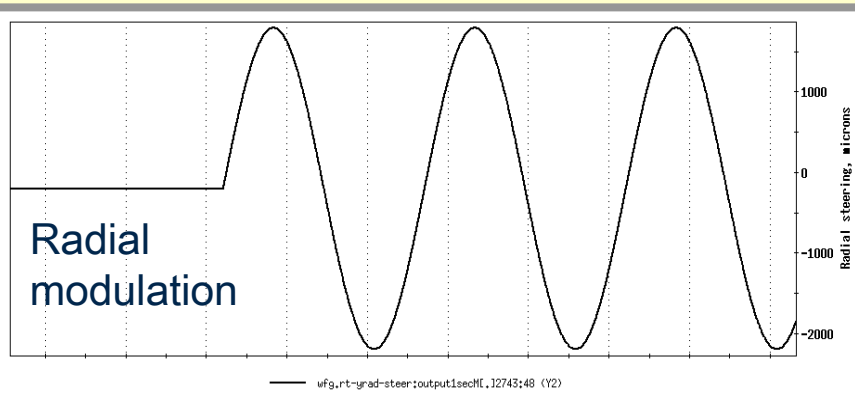
2mm amplitude at 0.2Hz

Prediction from model:





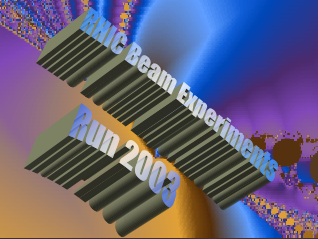
Nonlinear chromaticity - 2



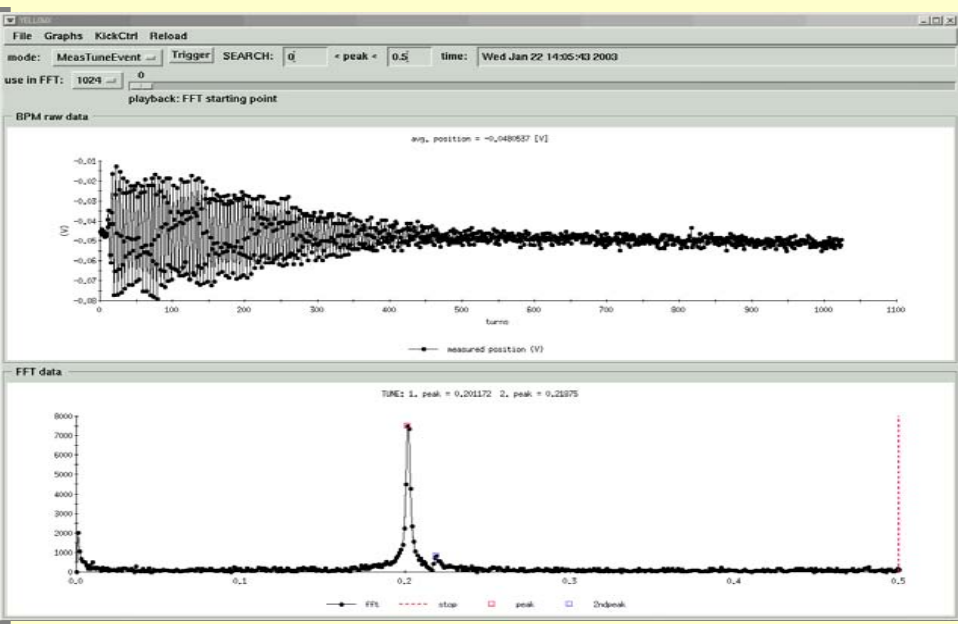
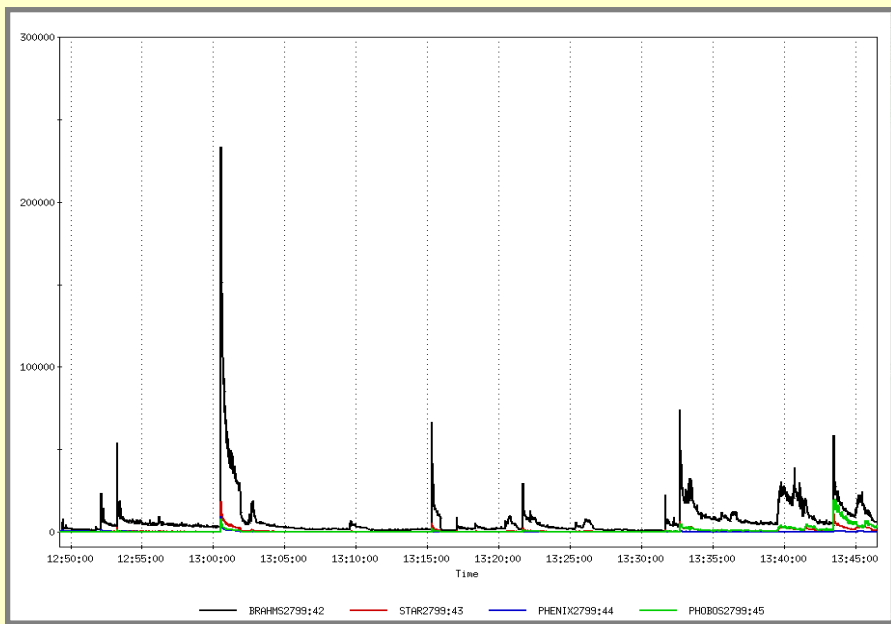
Good result for horizontal measurement
X2~1340 chrom application compare well
With pen&pencil calculation from PLL tunes

Next step:

- ☐ Clarify vertical result in Yellow
- ☐ Measure in Blue
- ☐ Use octupoles to compensate



Resonance compensation

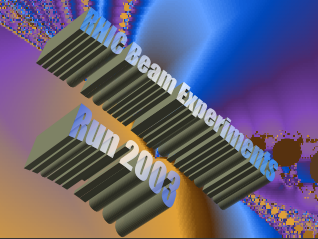


Goal: compensation of resonance lines $5Q_x$ (decapoles) and $4Q_x$ (octupoles)
useful at flat-top, transition

Tools: **BTF spectra**, **Schottky**, then TBT BPM + AC dipole (**res.driving terms**)

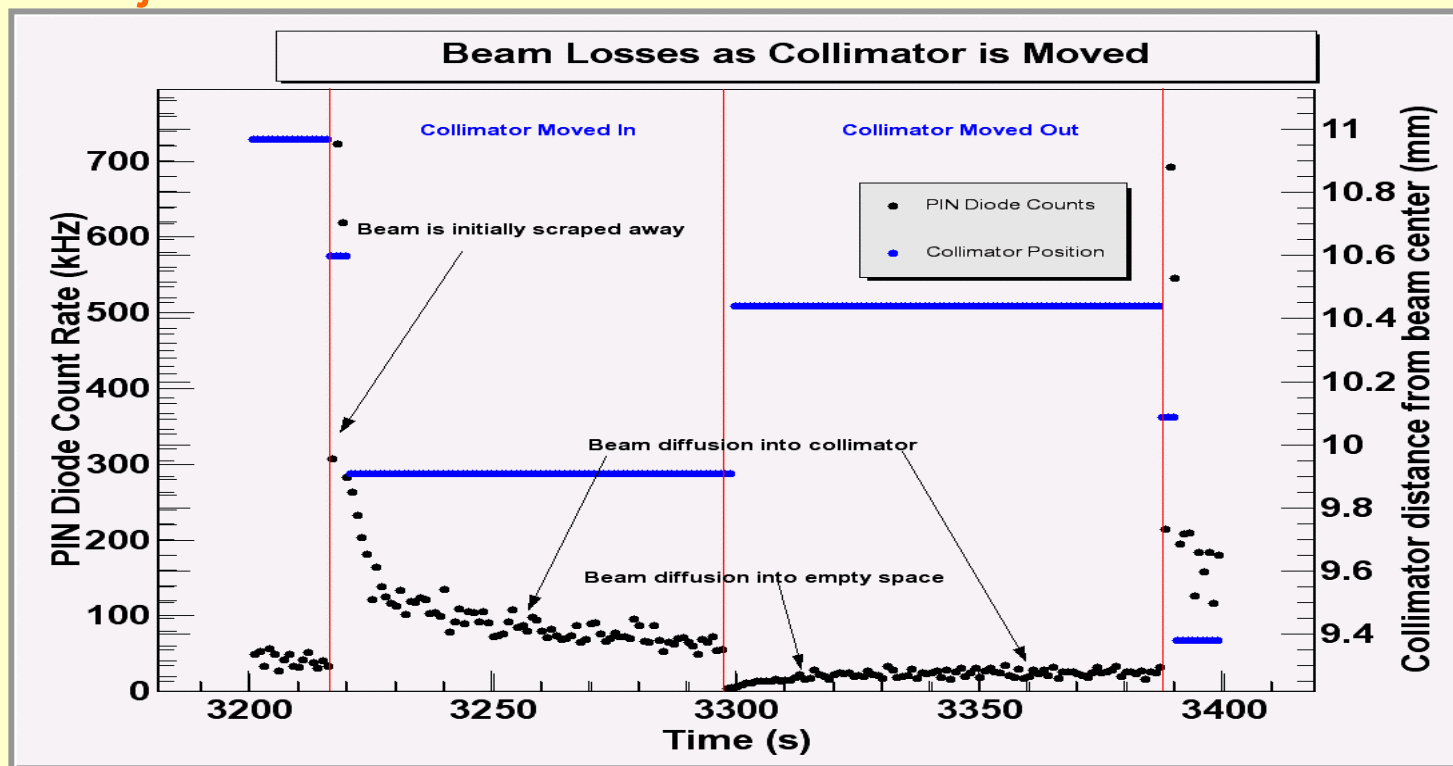
First time 2003: flat-top, approached 0.2 tuning on background + decapoles in Irs

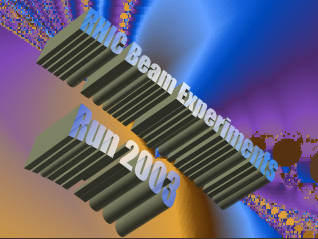
Next: injection, beam in island, understanding BTF, Schottky



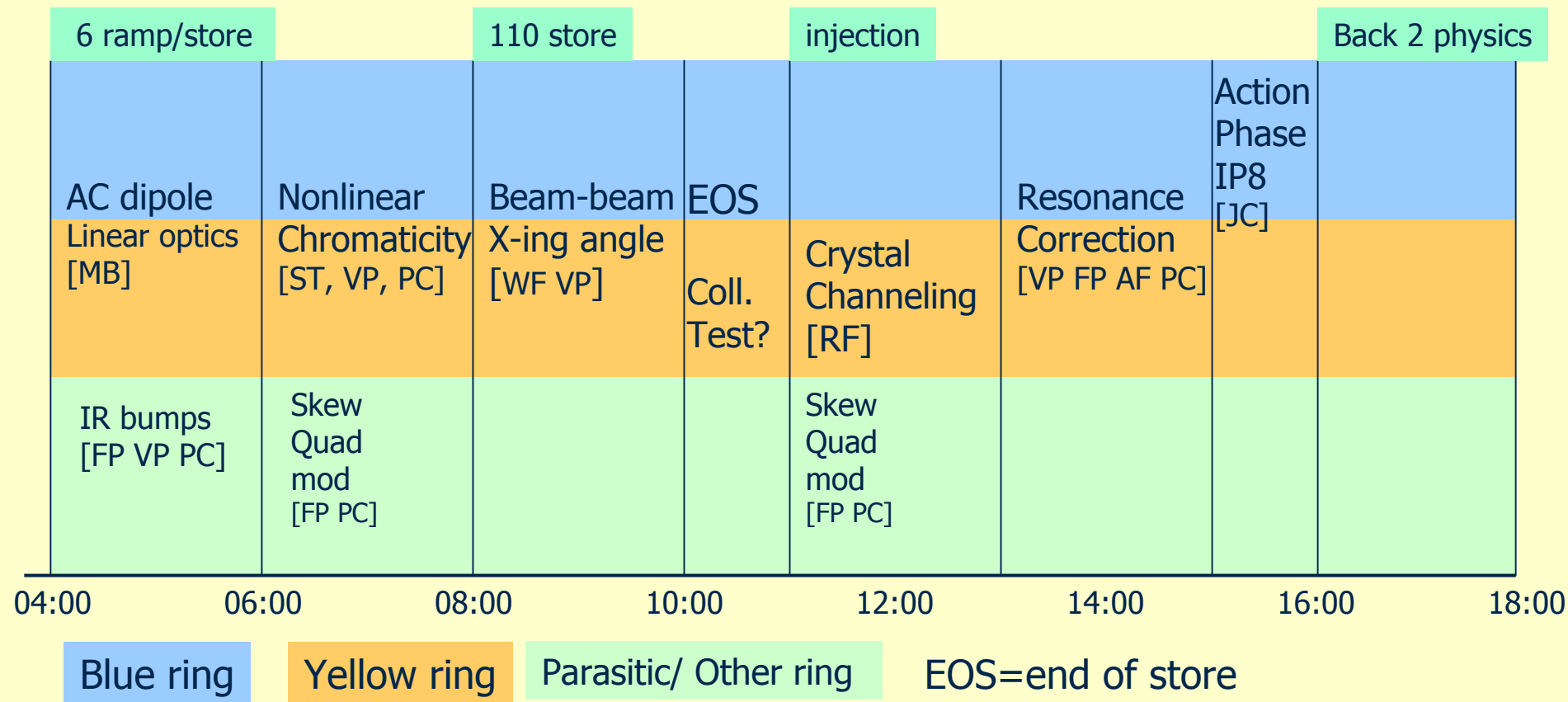
Diffusion at injection

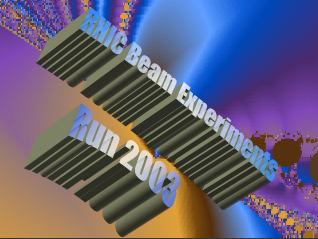
- By moving the collimator into and away from the beam and measuring the beam loss rate as a function of time → **diffusion coefficient**
- compare to calculations → find the driving factor(s) of **emittance growth**
- Compare **injection to store** conditions





Beam Ex Schedule February 5, 2003





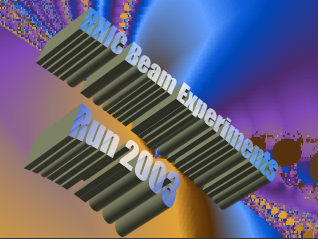
Medium term future: run 2003

8 remaining weeks of d-Au

- ☐ Pressure rise/e-cloud (pending beam intensity)
- ☐ Test of stochastic cooling
- ☐ Chromaticity: nonlinear, RF phase modulation, head-tail
- ☐ Coupling: AC dipole, skew quad modulation
- ☐ Beam-beam
- ☐ Flattop: resonance, triplets, IR correction

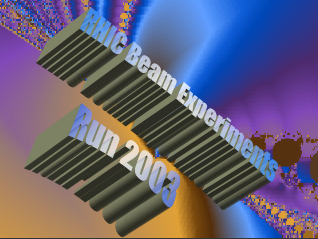
3 weeks of pp

- ☐ Beam-beam (coherent modes, resonance driving terms)
- ☐ Squeeze to betastar=0.5m
- ☐ Experiments with polarized beams



Long(er) term future

- ❑ Address RHIC upgrade scenarios
- ❑ Collaborative experiments of larger scale
(TeV, LHC, ?) including “class-2” experiments, more defined and possibly standing collaborations
- ❑ Remote operations/GAN-like activity
(ICFA working group on remote accelerator physics experiments is being created – chaired by David Rice – to coordinate efforts in this domain – active in 2-3 months)
- ❑ Organization of a workshop on beam experiments
(seeking ICFA endorsement) late in 2003 or more likely in
spring/summer 2004.



Last but not least.....

...being Friday and lunar new year, a final positive thought ☺

On both the professional and personal level it is a privilege to be working on this project with such a bunch of dedicated and talented people